CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-28

March 9, 1977

1. Name of fault(s): Red Mountain fault.

2. Location of faults: White Ledge Peak, Pitas Point and Ventura 7.5' quadrangles, Ventura County.

3. Reason for evaluation: Part of 10-year program; reported Holocene activity.

4. References:

Bortugno, E.G., 1977, work in progress (to be included in) Fault Evaluation Report FER- : California Division of Mines and Geology, unpublished report.

a) Buchanan, J.M., Ziony, J.I., and Castle, R.O., 1973, Recent elevation changes across part of the Transverse Ranges near Ventura, California: Geological Society of America, Abstracts with Programs, v. 5, p. 17.

b) Buchanan-Banks, J.M., Castle, R.O., and Ziony, J.I., 1975, Elevation changes in the central Transverse Ranges near Ventura, California: Tectonophysics, v. 29, p. 113-125.

c) Dibblee, T.W., Jr., 1947, Unpublished geologic map of the "Ventura" quadrangle, scale 1:62,500.

d) Dutton, W.G., 1962, The geology of the Casitas Pass region, Ventura County, California: Unpublished M.A. thesis, University of California, Los Angeles, 75 p., 3 plates, geologic map scale 1:18,000.

e) Geotechnical Consultants, Inc., September 30, 1969, Final Report of Grading Control, Mobil Oil Rincon Shore Facility, County of Ventura, California for Mobil Oil Corporation, Job-CVB1013: Unpublished consulting report, on file with Ventura County

Public Works Agency (earlier reports on the same site, completed by the same consultants are also on file).

f) Gonzales, J., November 18, 1976, oral communication; Geotechnical Consultants, Inc.

g) Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs, and thermal wells: California Division of Mines and Geology, California Geologic Data Map Series, Map no. 1, scale 1:750,000.

h) Jennings, C.W., and Strand, R.G., 1969, Geologic map of California, Los Angeles sheet: California Division of Mines and Geology, scale 1:250,000.

i) Nichols, D.R., October 1974, Surface faulting <u>in</u> Seismic and Safety Elements of the Resource's Plan and Program: Ventura County Planning Department, Section II, p. 1-35, plate 1.

j) Putnam, W.C., 1942, Geomorphology of the Ventura region, California: Geological Society of America Bulletin, v. 53, p. 691-754, 5 plates, 11 figures.

k) Vedder, J.G., Beyer, L.A., Junger, A., Moore, G.W., Roberts, A.E., Taylor, J.C., and Wagner, H.C., 1974, Preliminary report on the geology of the continental borderland of southern California: U.S. Geological Survey Miscellaneous Field Studies Map MF-624, 34 pages, 9 plates, geologic map scale 1:500,000.

l) Weber, H.F., Jr., October 28, 1976, oral communication.

m) Weber, H. F., Jr., Cleveland, G.B., Kahle, J.E., Kiessling, E.F., Miller, R.V., Mills, M.F., Morton, D.M., and Cilweck, B.A., 1973, Geology and mineral resources study of southern Ventura County, California: California Division of Mines and Geology, Preliminary Report 14, 102 p., map scale 1:48,000.

n) Weber, H. F., Jr., Kiessling, E.W., Sprotte, E.C., Johnson, J.A., Sherburne, R.W., and Cleveland, G.B., 1975, Seismic hazards study of Ventura County, California: California Division of Mines and Geology, Open File Report 76-5LA, 396 p., 9 plates, map scale 1:48,000.

o) Willott, J.A., 1972, Analysis of modern vertical deformation in the western Transverse Ranges: Unpublished M.A. thesis, University of California, Santa Barbara, 81 p.

p) Ziony, J.I., Wentworth, C.M., Buchanan-Banks, J.M., and Wagner, H.C., 1974, Preliminary map showing recency of faulting in coastal southern California: U.S. Geological Survey, Miscellaneous Field Studies Map, MF-585, 15 p., 3 plates, map scale 1:250,000.

5. Summary of available information:

The earliest published data on the Red Mountain fault comes from Putnam (1942, p. 709), who described the fault as below:

> "The Red Mountain thrust extends westward on the south side of Red and Rincon mountains for 13 miles from the western end of Sulphur Mountain to the sea at Rincon Point. The fault trace curves sharply from north-south east of the Ventura River to east-west on the west side of the river. This change in trend is closely related to the Red Mountain dome. The fault dips north or west at 40° to 65° through most of its length and thrusts Miocene strata over Pliocene, except near Padre Juan Canyon where lowermost Pico ("Repetto") shales are brought in contact with uppermost Pico clay shales.
> "The thickness of each Miocene formation cropping out on Sulphur Mountain averates about 2000 feet. West of the Ventura River the same formations north of the fault are attenuated fault-slivers only a few hundred feet thick. There is little breccia along the

fault, despite the displacement of several thousand feet, and evidence of faulting is often difficult to find. This is true in Padre Juan Canyon where Pliocene shales, lithologically, nearly identical and normally several thousand feet apart, are in fault contact. The fault is marked by only a 6-inch band of gouge exposed in an excavation for an oil well at the head of a small tributary of Madranio Canyon. Here the sharply defined fault plane dips 65° N.

"The Red Mountain thrust is still active and has displaced the 500-foot marine terrace on Rincon Mountain and arched the Ventura River terraces."

Putnam's map (attached) is on a planimetric base, and is too small a scale to be replotted on Plate 2 with any accuracy.

Dibblee's (1947) reconnaissance map of the "Ventura" quadrangle shows the Red Mountain fault as cutting Pico Formation (Pliocene) but not cutting Late Quaternary terrace deposits. Dibblee's Red Mountain fault traces ~~is~~ are shown on plate 2. Dibblee's mapping was utilized by Jennings and Strand (1969) and ~~, in turn,~~ by Nichols (1974). Nichols considered the Red Mountain fault as part of the "Red Mountain-San Cayetano-Santa Susanna-San Fernando Fault System" but admitted that a wide gap exists between the Red Mountain and San Cayetano faults. Nichols considered the system "active", noting:

> "Geologic evidence that the fault system should be considered active throughout its length is shown by location of earthquake epicenters (including the San Fernando Earthquake of 1971), ground water barriers, and displaced alluvial sediments. In addition, the unusually high fluid pressures in the Ventura and San Miguelito oil fields are believed to indicate that tectonic stress has accumulated along that section of the fault system between the Red Mountain and San Cayetano faults. It is possible that contained build up of this stress will eventually result in sudden release, probably in the form of an earthquake resulting from movement along one or more of the faults within the Ventura County portion of the system."

Dutton (1962) mapped a fault which he thought might be a trace of the Red Mountain fault (see plate 2), since it was a north-dipping thrust fault. The youngest unit cut by the fault, as he mapped it, is

Rincon Formation (lower Miocene). This fault is not overlain by any younger units, except landslides. Dutton makes no note of the age of the fault and notes that the amount of offset is unknown. The main traces of the Red Mountain fault, as mapped by Dibblee (1947), and as mapped by Weber, et al. (1973, 1975) are south of Dutton's field area.

The traces of the Red Mountain fault shown in Weber, et al. (1973), and Weber, et al. (1975), are the same. The traces were compiled from an anonymous source and is the best data available (Weber, oral communication, 1976). Weber, et al (1973, p. 41) state:

> "The Red Mountain and San Cayetano thrust fault zones, which together nearly span the County should be considered active. Holocene and Pleistocene sediments are displaced by the Red Mountain thrust, and similar physiographic features on both the Red Mountain and San Cayetano thrusts, also suggest Holocene displacement. In addition, aerial photos show many ground surface lineaments and other phenomena which may reflect Holocene or late Quaternary faulting, and should be investigated.

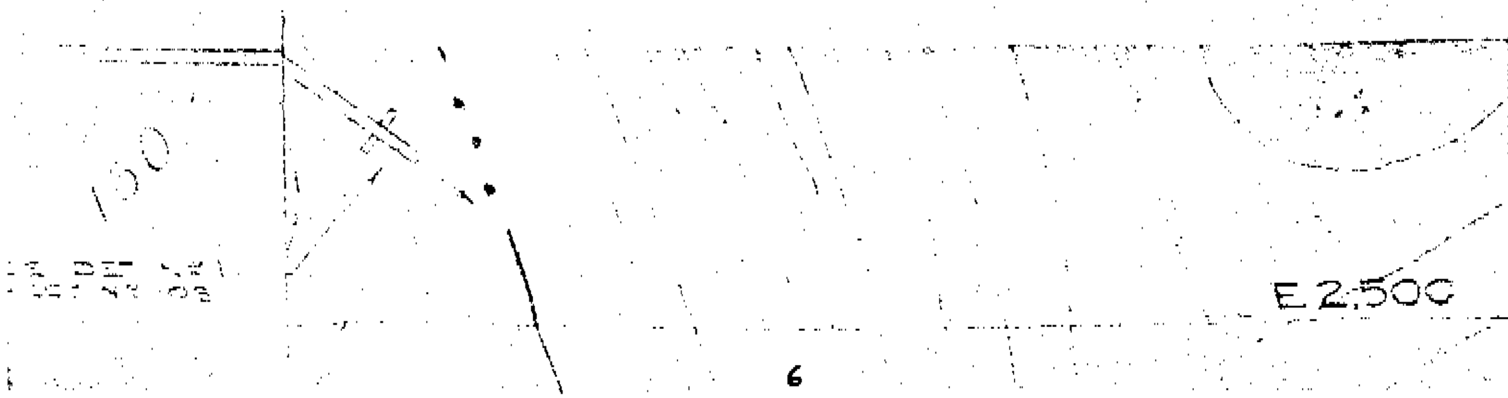
Weber, et al (1975, p. 174), in discussing the "probable age of latest movement" concluded that the Red Mountain "zone" is "Late Quaternary (Holocene in western-most portion)", based on Ziony, et al (1974), and Buchanan and others (1973).

Perhaps the most definitive work was done by Geotechnical Consultants, Inc. (1969). Several earlier versions of the 1969 report, each with slightly different titles, are filed with the Ventura County Public Works Agency. Joe Gonzales (1976) noted that the Red Mountain fault crossed the Mobil Oil site and that he believed it was active. Geotechnical Consultants, Inc. dug several trenches, one thirty-five feet deep (it didn't get below the soil), and made several borings. They were unable to identify any fault and finally gave up. Later,

Figure 1. from Geotechnical Consultants, Inc., 1969

LEGEND

af	ARTIFICIAL FILL
Qls	LANDSLIDE
Qco	COLLUVIUM
Qn	NECROGINITE, FAULT SCARP TALUS THAT HAS BEEN IN PART OVER-RIDDEN BY AN EROSION THRUST
Qt	QUATERNARY TERRACE (FLUVIATILE IN ORIGIN)
Qc	CARPINTERIA FORMATION (MARINE BEACH SANDS AND GRAVELS)
Pp	PICO FORMATION (sltst - siltstone), (ss-sandstone), (cg-conglomerate)
Pr	REPETTO FORMATION-SILTSTONE
Mu	UPPER MIOCENE-SHALE
	GRADED FLAT AREA
37	ATTITUDE OF BEDDING, DOTTED WHERE COVERED WITH FILL
13	ATTITUDE WITH LONG STRIKE SIGHT LINE
81	ATTITUDE OF JOINT
	VERTICAL JOINT
25	ATTITUDE OF SHEAR PLANE OR FAULT
30	ATTITUDE OF CONTACT
65	OVERTURNED BED
90	VERTICAL BED, TICK POINT TOWARD STRATIGRAPHIC TOP OF BED
	CONTACT BETWEEN FORMATIONS, DOTTED WHERE COVERED OR INFERRED
	EITHER BEDDING OR BOUNDARY OF LITHOLOGIC MEMBER, DOTTED WHERE INFERRED OR COVERED
44	TRACE OF FAULT, SHOWING DIP, DOTTED WHERE COVERED OR INFERRED
	BOUNDARY OF EXISTING GRADING FEATURES AS APPROXIMATELY DETERMINED IN THE FIELD
	BROW OF EXISTING CUT SLOPE AS APPROXIMATELY DETERMINED IN THE FIELD
24+00	REVISED ROAD STATION



after a road-cut was made to provide access to the oil facility, they inspected the cuts for the final as-graded report. The log of the cut is reproduced here as figure 1. There are two fault traces, one of which offsets the base of the topsoil (which was not dated), and both of which offset older soil horizons and terrace deposits. In addition, they also noted a more steeply dipping fault, which they called the Mud Pit fault. This trace also cut terrace deposits (south of area shown on plate 1), but did not offset the soil. The Mud Pit fault could be the southernmost trace of the Red Mountain fault zone, as mapped by Weber, et al. (1975), or Dibblee (1947). One should note that the Mud Pit fault dips to the east and southeast.

Ziony, et al. (1974) classify the offset soil horizon noted above as Holocene, and thus, assign~~s~~ an age of Holocene to their entire northernmost trace of the Red Mountain fault as well as to a queried trace immediately west of the Geotechnical Consultants, Inc. site. To the southernmost trace of Weber, et al. (1973, 1975) they assign a late Quaternary age, using offset terrace deposits as evidence. Weber, et al. (1975) use Ziony, et al. as a reference and indicate~~d~~ a Holocene age for the western end of the Red Mountain fault; however, Weber, et al concluded that the remaining fault traces were late Quaternary.

Immediately north of the western end of the Red Mountain fault, both Weber, et al. (1975), and Ziony, et al. (1974) depict several fault traces or lineaments that may be a part of the Carpenteria fault (see Bortugno, 1977), or the Red Mountain fault zone.

Two other reports, based on first-order leveling are pertinent. Willott (1972) concluded that there was 2 cm. of vertical movement, over a 14-year period, across the Red Mountain fault near Highway 101. Buchanan, et al. (1973) and Buchanan-Banks, et al. (1975 -- a revision of the 1973 reference in which the raw data has been corrected) also note similar changes in elevation between 1939 and 1971. The slight changes in elevation (130 mm. between stations K569 and M569 -- see plate 2) identified along the coast were discounted by the authors because of the possibility of man-induced subsidence in the oil fields south of the fault. A profile along State Route 150 (now State Route 33), however, showed a marked change in elevation, even though non-tectonic (oil field) subsidence occurred along the Ventura anticline. Survey points approximately 3 km to the north of the anticline showed an apparent (corrected) uplift of 0.14 m. between 1939 and 1968. Thus, one may conclude that strain is either accumulating or being released in the vicinity of the Red Mountain fault. However, there is no reported case of creep occurring on any dip-slip fault anywhere in the world. Therefore, the former is probably the case.

Gonzales (1976) reported some buckled concrete slabs in a drainage channel adjacent to the water treatment plant, which is in the Ventura River flood plain, and lies on trend with the Red Mountain fault. He stated the channel deposits are less than ten feet deep under the plant, and felt that the bukling could be due to "creep" along the Red Mountain fault. The city, upon learning about the damage, and the theory, immediately repaired the ditch, removing the evidence.

6. Interpretation of air photos:

Fairchild air photos (from the Whittier Collection) flight C297B, numbers A1 through A6 and B10 through B18, flown in 1920, were examined stereoscopically. (Prints have been requested for our files.) Features observed are noted on plate 2. Also viewed were photos numbers A8 through A12, from flight C509 (1929). These latter photos were very grainy, and the critical ground locations had been recently plowed. No fault-related features were obvious that had not already been recognized on flight C297B.

The information plotted on plate 2 is based on a one hour examination of these air photos; plates 3 and 4 show data based on an additional 20 hours of air photo interpretation. Thus, plates 3 and 4 present the more detailed air photo data.

In general, I was impressed with the numerous landslides in the area (plates 3 and 4), which tend to obscure possible fault features. West of Los Sauces Creek the most recently active fault trace is marked by an obvious scarp, about 20 feet high and 100 feet wide. This scarp is not obvious elsewhere. A tonal lineament which could be the trace of the low angle thrust which cuts the soil, is shown as a sinuous lineament between the scarp in the terrace and Los Sauces Creek.

East of Los Sauces Creek, there are also some tonal lineaments, and some obvious changes in slope. However, the strata are approximately parallel to the fault; thus, many or all of these lineaments could be due to bedding.

A number of scarps, in bedrock also were noted (see plates 2 and 3).

However, most of these scarps appear to be oriented such that, if these features are actually fault scarps, the faults would be nearly vertical or dip steeply to the south. The main fault (figure 1), which is ~~known to cut~~ shown as cutting the soil, is gently north-dipping. At least three explanations of these scarps are possible. First, they could be the heads of old landslides which have been highly dissected. Second, they could be the result of movements on other (secondary) faults within the Red Mountain fault zone. Third, these features could be due to differential erosional of the bedrock units.

7. Field observations:

Field observations are noted on plate 2. One important site west of Los Sauces Creek was visited by me and other Division staff on December 12, 1976. This was the road cut logged by Geotechnical Consultants, Inc. (1969). Here ~~the~~ a soil (or colluvial?) horizon was obviously overthrust by older materials. This relationship is shown in photo 1 and figure 1. This same site was visited again in January 1977. I attempted to follow this fault trace to the east. A few closely spaced branch faults were noted (not plotted -- there were too many, "short"faults to plot for the map to still be legible). These branch faults and the native vegetation, coupled with the fact that the fault was not expressed in the topography made it difficult to follow this most recent trace of the fault. However, this trace may follow closely the tonal lineament west of Los Sauces Creek (plate 3). The stream deposits along Los Sauces Creek did not appear to be displaced, but these deposits may not be more than a few hundred years old. East of Los Sauces Creek the slopes were more densely vegetated. Several fault traces, the dips of

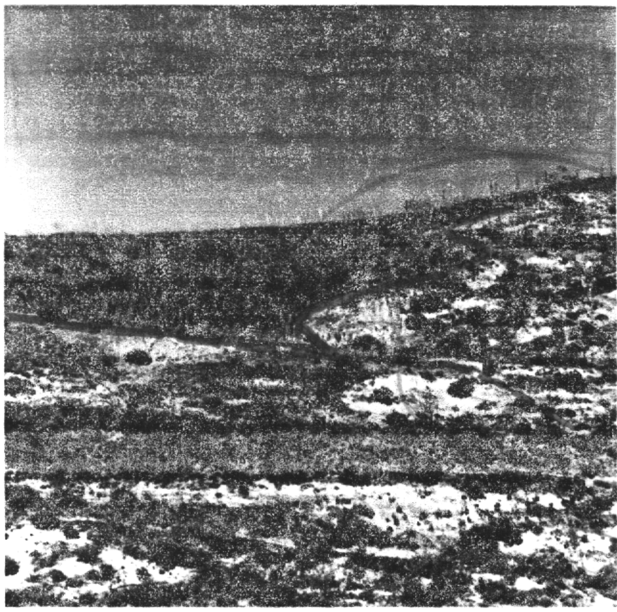
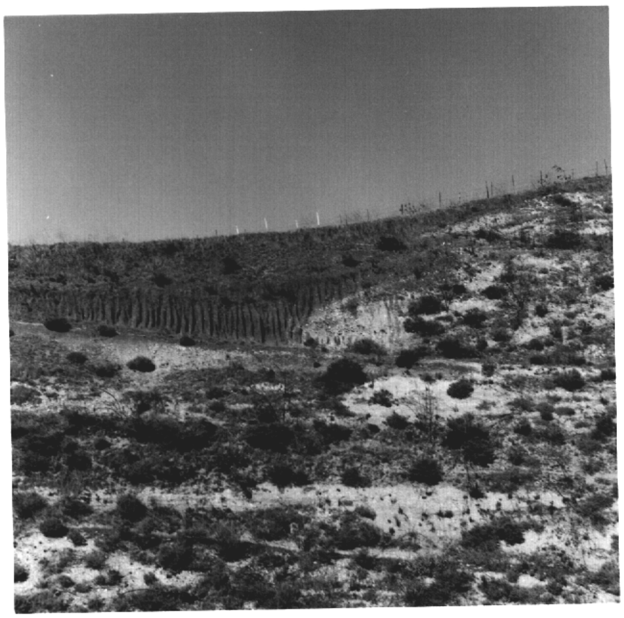


Photo 1. The Red Mountain fault near Los Sauces Creek. View, looking west, of the offset soil horizon referred to in the text. Late Pleistocene terrace deposits (and older units) are thrust over soil at this location



which ranged from about 40° north to 75° south, were noted in the bedrock east of the creek. I could not determine which of these traces was the most recently active trace, but I did note that more fault traces are present than have been mapped previously.

Additionally, Earl Hart and I visited the area west of Los Sauces Creek in May 1976. At that time we did not see the road cut mentioned above, nor were we convinced that any geomorphic features were present that would conclusively demonstrate that recent faulting had occurred. We did note at least two small faults offsetting terrace deposits (northeast side down) in sec. 1, T. 3 N., R. 25 W. and sec. 6, T. 3 N., R. 24 W. These faults did not appear to be topographically expressed, nor was the soil above apparently affected by them. It was not clear whether these faults were a part of the Red Mountain thrust (secondary normal faults in the upthrown block) or were a part of some other fault system.

8. Conclusions:

West of Los Sauces Creek, the Red Mountain fault appears to be fairly well-defined. The fault is known to cut a soil horizon and thus, may be considered sufficiently active for zoning under the Alquist-Priolo Special Studies Zones Act. However, this soil has not been dated and cannot, therefore, be used as conclusive proof of Holocene fault activity.

East of Los Sauces Creek, however, I must question the adequacy of the existing geologic maps. First, the most recently active trace is a low angle thrust near Los Sauces Creek, but the faults east of the creek mapped by Weber, et al. (1975) and Dibblee (1947) do not appear to be low angle thrusts. In addition, Dibblee shows his mapped faults as not cutting terrace deposits (he also showed the fault as buried under the terrace west of Los Sauces Creek). Putnam (1942) noted the difficulty in mapping the Red Mountain thrust, specifically noting that there were several traces a few hundred feet apart. Apparently, there are many faults in the area. Although certain traces may be well-defined locally, the most recently active or principal trace(s) does not appear to be well-defined. This is in part due to the steep terrain, the numerous landslides, and the difficulties inherent in recognizing thrust fault features. The same may be said for the other faults and photo lineaments north of the well-defined trace east of Los Sauces Creek. Also, the only evidence or probable Holocene activity is along the well-defined trace west of Los Sauces Creek.

Secondly, Weber, et al. (1975), concluded that the Red Mountain fault was probably Holocene in the westernmost part and late Quaternary (non-specific) in the eastern part. I have found no evidence to the contrary, except possibly for the Buchanan-Banks, et al. (1975) data. However, these leveling data cannot be attributed to a single specific fault trace and may be distributed over at least a 3-mile wide area.

Finally, my own limited work in the Pitas Point quadrangle (plate 3) suggests that the Red Mountain fault is most likely to be active north of the principal mapped traces, and thus, may lie outside of the Special Studies Zone that may be established on the basis of existing data.

9. Recommendations:

Those traces noted on plate 3 should be zoned. Zoning of the Red Mountain fault east of Madranio Canyon is not feasible at this time. More definitive data on the location of the active trace is in this area, if indeed, there is an active trace, is needed.

10. Investigating geologists name; date:

Theodore C. Smith
THEODORE C. SMITH
Assistant Geologist
March 9, 1977

I agree with the recommendation to zone that portion of the Red Mtn fault west of Los Sauces Creek. In so doing, it is recognized that not all of the active faults that may exist will be encompassed within the proposed Special Studies Zones. Further zoning should await better data.

EWH
4/4/77

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Map from Putnam, 1942.

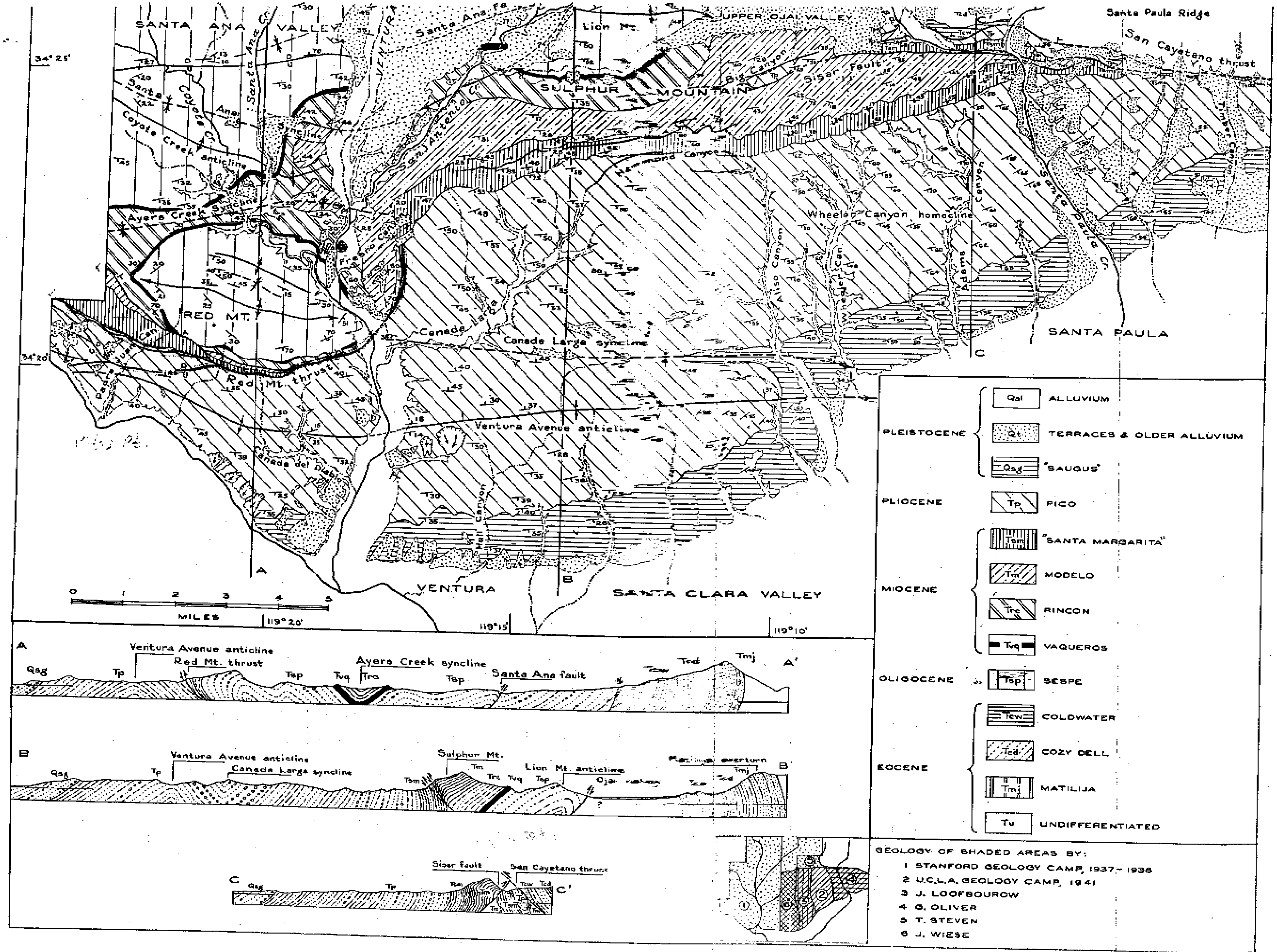

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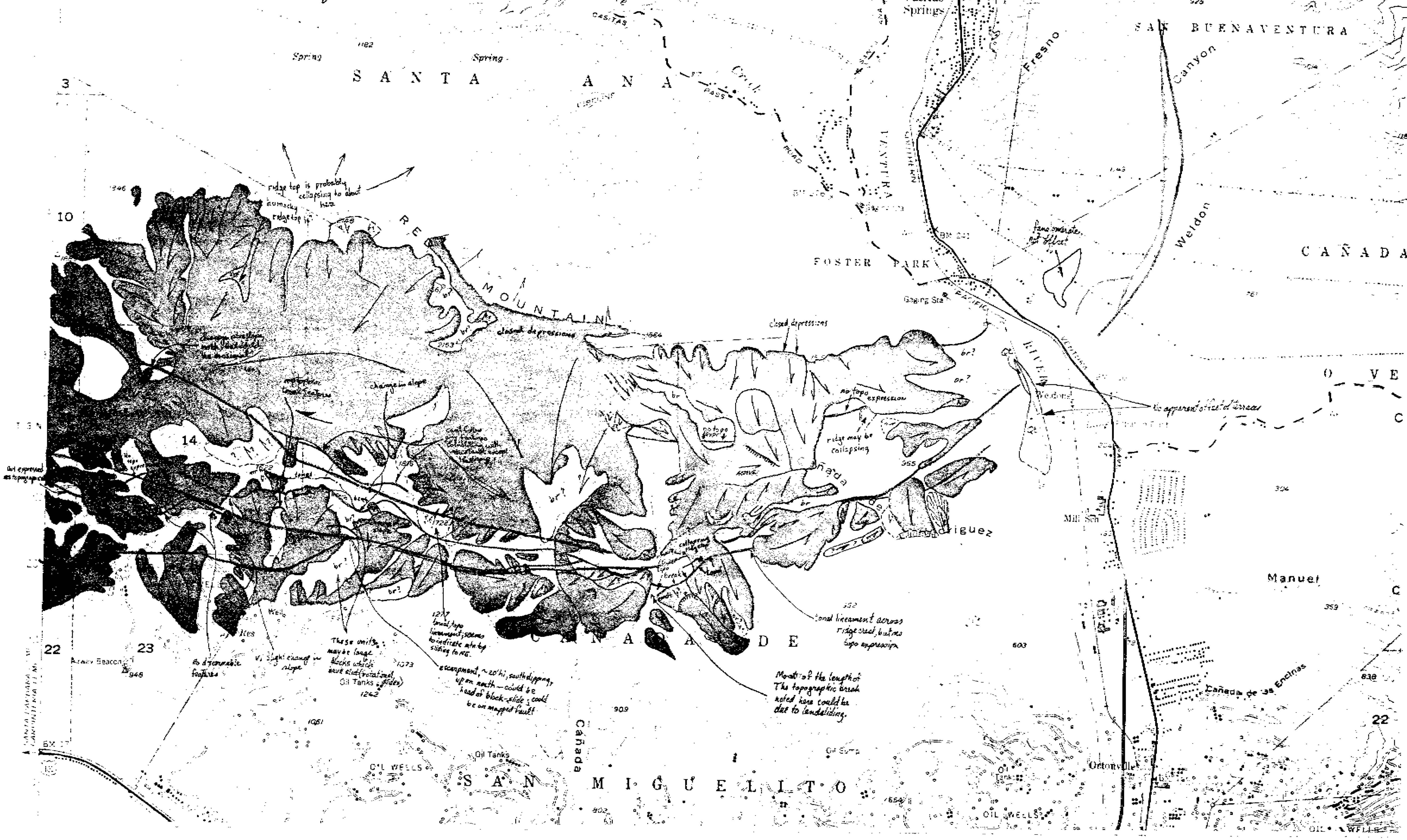
PLATE 4 The Red Mountain Fault in Ventura Quadrangle

For legend, see plate 3.



EXPLANATION

MAP SYMBOLS

LINE SYMBOLS

Onshore fault

Queried where connection, continuation, or existence uncertain; dotted where inferred beneath covering deposits. Star indicates fault with relatively young movement along it but fault trace too short to show at map scale

GEOLOGIC CONTROL SYMBOLS

Indicate location and age of late Cenozoic geologic features that bracket the latest movement for each fault. Numbers within the symbols indicate the age of each geologic control as based on the generalized time spans of the age range chart; the youngest reasonable age is assumed for deposits whose age is uncertain

○ Oldest known unfaulted stratigraphic unit that is deposited across or intruded along the fault. Age of unit provides minimum limit on age of latest movement

□ Youngest known stratigraphic unit displaced by fault. Age of unit provides maximum limit on age of latest movement

◁ Fault-produced geomorphic feature. Age of feature provides maximum limit on age of latest movement

Fault is classed as Unknown (U) because no faulted late Cenozoic deposits are preserved along it. A minimum limit on age of movement is lacking.

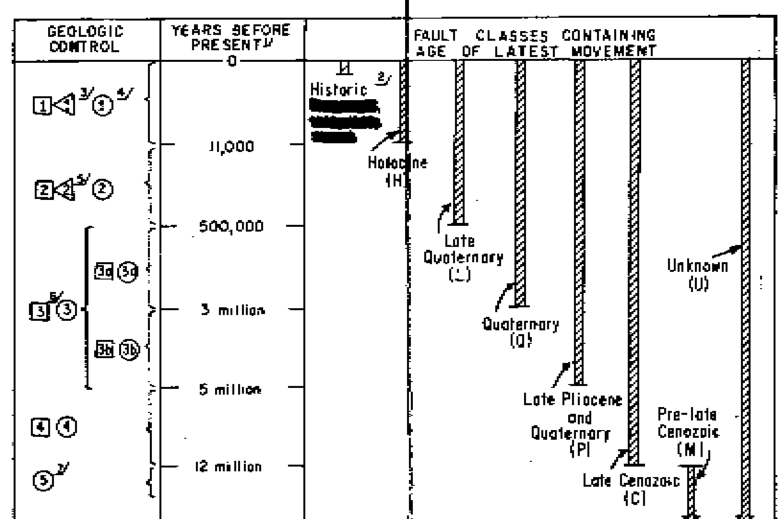
Fault is classed as Unknown with minimum limit on age of latest movement (Um). No faulted late Cenozoic deposits are preserved along it, but the latest movement predates unfaulted early Pleistocene marine strata between about 3 million and 500,000 years old (circle with numeral 3a).

Explanation from Ziony, etal, 1974 (with slight editing).

Red Mountain fault

Seven of the eight age classes enclose progressively longer spans of time within which movement may have occurred (see chart). The time span containing the latest movement may be restricted further by unfaulted overlying deposits indicated on the map by minimum geologic control symbols. Faults lacking evidence of late Cenozoic movement are designated Unknown. If positive evidence exists that they have not moved for at least 12 million years, they are classed Pre-late Cenozoic; faults classed as Unknown (U) could have moved as recently as those of any other age class, except for those faults of unknown age with minimum age control (Um)

AGE RANGE CHART OF GEOLOGIC CONTROLS AND AGE CLASSES



1/ Years are approximate and are based in part on radiometric dates from strata in southern California. Column is not to scale

2/ Queried where nature of ground rupture is questionable. [redacted]

3/ Geomorphic criteria for Holocene faulting: sag depression; offset stream course in Holocene deposits; linear scarp in Holocene deposits; or, linear submarine scarp in seafloor sediments above wave base

4/ Control from overlapping Holocene strata not shown on map except where such deposits are known to be at least 3,000 years old

5/ Geomorphic criteria for late Quaternary faulting: offset stream course in Pleistocene or older deposits; linear scarp in Pleistocene deposits; markedly linear steep mountain front associated with adjacent concealed fault trace; or, linear submarine scarp in seafloor sediments below wave base

6/ Numeral 3 designates nonmarine strata of late Pliocene to early Pleistocene age. Numerals 3a and 3b designate marine strata of early Pleistocene and of late Pliocene age, respectively

7/ Pre-late Cenozoic minimum geologic control consists of intrusive rocks about

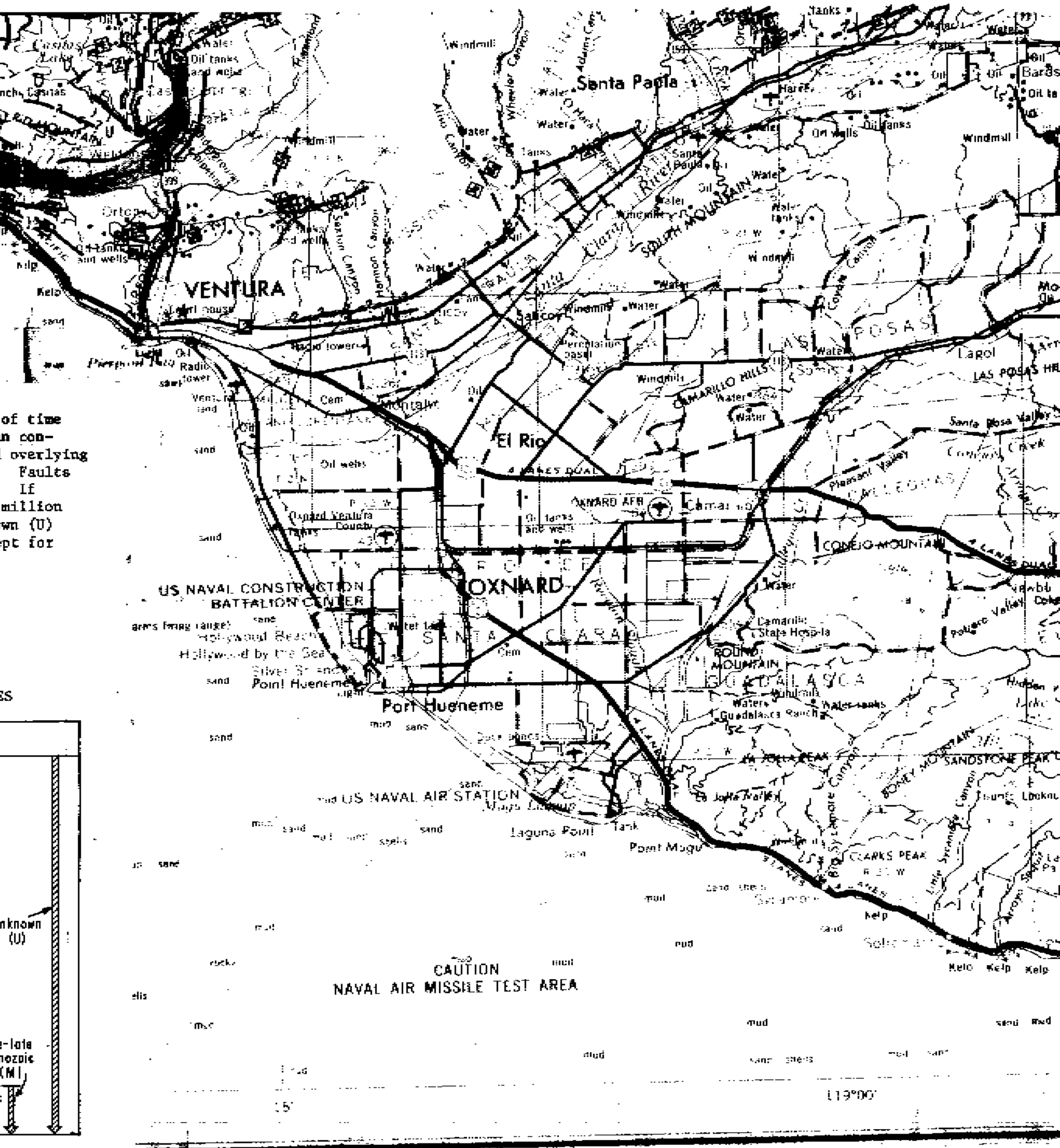


Plate 1. Index map of the Red Mountain fault showing evidence for recency of fault movement. By T.C. Smith after Ziony, etal., 1974.

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